LIGHTING DATA

EDISON LAMP WORKS
OF GENERAL ELECTRIC COMPANY

GENERAL SALES OFFICE HARRISON, N. J.

The Lighting of Signs and Billboards

Illuminated

Information compiled by

J. M. SHUTE,
Lighting Service Department

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Synopsis:

For information regarding Mazda lamps and lighting questions, refer to the nearest sales office.

To insure receipt of bulletins, notify the Department of Publicity, Edison Lamps Works of the General Electric Company, Harrison, N. J., of any change of address.

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Introductory

Illuminated signs are almost as old as history itself, but until the development of the incandescent lamp, lighted signs were crude and rare on account of the impossibility of effectively applying such light sources as were available. The electric signs which we now see on every hand are indeed a new development.

The first electric sign of which we have record was used shortly after the commercial use of the incandescent lamp had been demonstrated. This sign, made by Major Hammer in 1882, which very appropriately spelled the word "EDISON," was used at the International Exposition at the Crystal Palace, in London. It was of what is now called the flasher type, operated by hand switches.

Even after this use of the incandescent lamp was demonstrated, quite a period of time elapsed before its commercial advantages were realized. However, following this realization the art of sign lighting made rapid progress, but its general adoption was prevented by the high current consumption of the old carbon lamp.

The MAZDA lamp overcame this difficulty and since the commercializing of this high efficiency illuminant, the adoption of electrically illuminated signs as an advertising medium has been general.

At the outbreak of the World War, it was deemed advisable to curtail sign lighting for the psychological effect and naturally, during the period of conservation, the art received a decided setback. However, with the advent of peace, and the development of new types of lamps, interest in sign lighting has been revived to such an extent that the business in this field has grown by leaps and bounds, making the subject one of importance to the engineer, central station and others.

Illuminated signs are valuable in attracting the eye as a result of their contrast against some background (a building or the sky). This contrast is produced in three manners:

1. Visible brilliant lamps used to spell the message or as a part of the decorative scheme.
2. Transmitted light or silhouette effects with concealed lamps as in transparencies.
3. Reflected light; illuminated painted signs and billboards.

Frequently these methods are combined on one sign.

These classes may be treated separately, which is the method followed in this bulletin. In order that the material in this bulletin may be discussed intelligibly, the system of nomenclature given in Fig. 1 is arbitrarily used throughout the article.

Signs with Visible Lamps

Signs which fall under this class are the most universally used of any type. They vary in size from huge roof signs which send their glittering messages to the inhabitants of our great metropolitan cities to the small signs over the doorway of the village store. Signs of this type interest us chiefly on account of their wide usage, and because they present such a multiplicity of design problems.

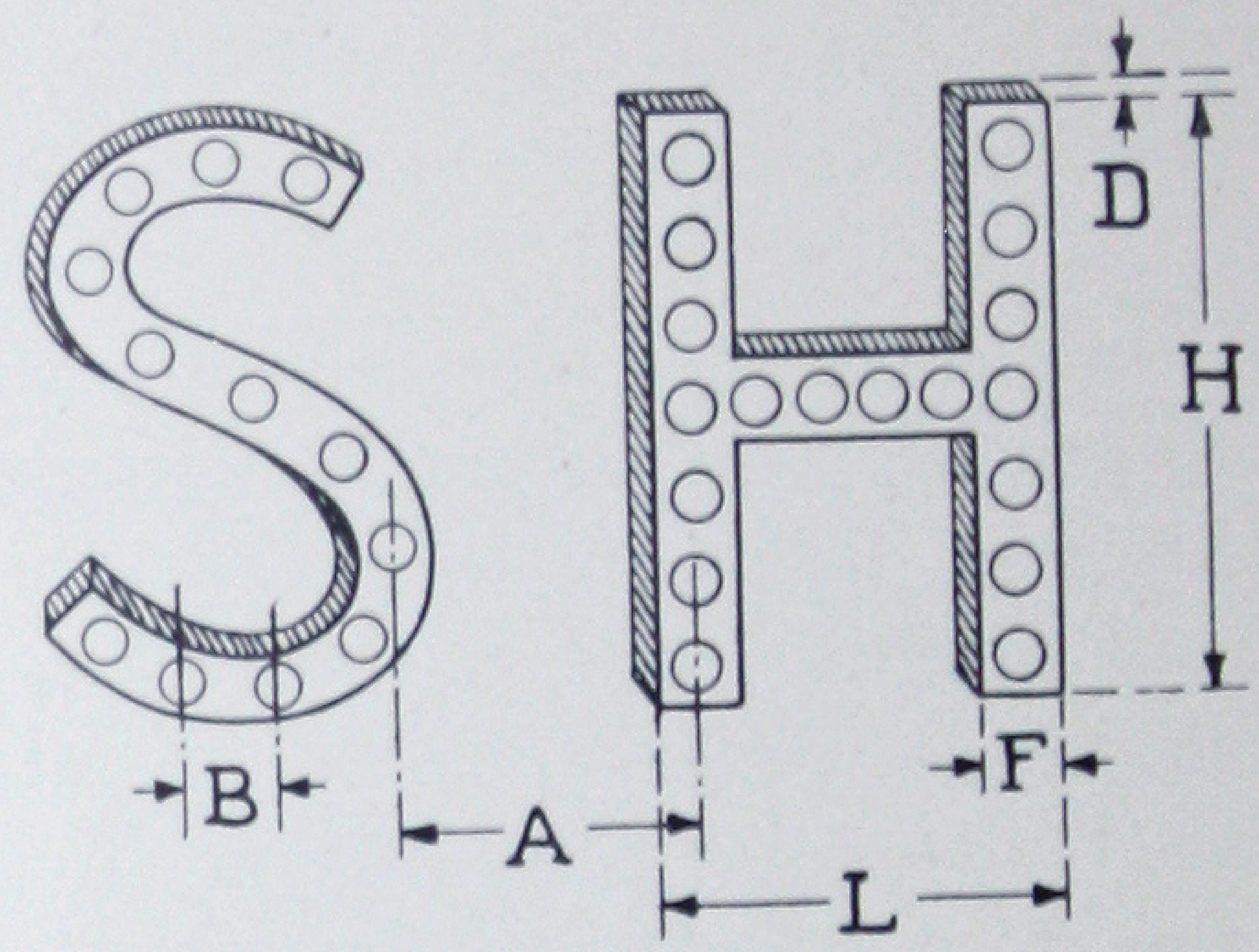

Fig. 1
Nomenclature. A—Spacing distance between letters, B—Spacing distance between lamps, D—Face depth of letter, F—Face width, H—Letter height, L—Letter length

The readability of a sign letter is influenced by a number of elements. Aside from the ocular peculiarities of individuals and the atmospheric conditions, such factors as the spacing and size of letters and the size, finish, spacing and color of lamps determine the size of the sign necessary for given service.

Design of Letters—Spacing

It is known that the human eye can distinguish as separate objects things so spaced that the angle subtended by them and the eye exceeds one minute. Therefore, in constructing signs if the various letters are spaced so that the distance between any two subtends an angle of at least one minute at the distance which has been determined the maximum at which the sign is to be read, each letter can be seen as a separate letter. Thus, from Fig. 2, the letters "SE" can be read from a greater distance than the same sized letters "HL," since the former have a wider spacing distance

between letters than the latter. However, in common practice, it has been found that spacing distances varying from 40 to 60 per cent of the letter height give the best results for roof signs though in special cases spacing distances of over 75 per cent of the letter height have been used.

Size

The size of the letter is another factor governing the readability of the sign. Proportions of each letter must be such that the letter appears clear to the observer. It has been found in common practice that letters having a length equal to two-thirds or three-

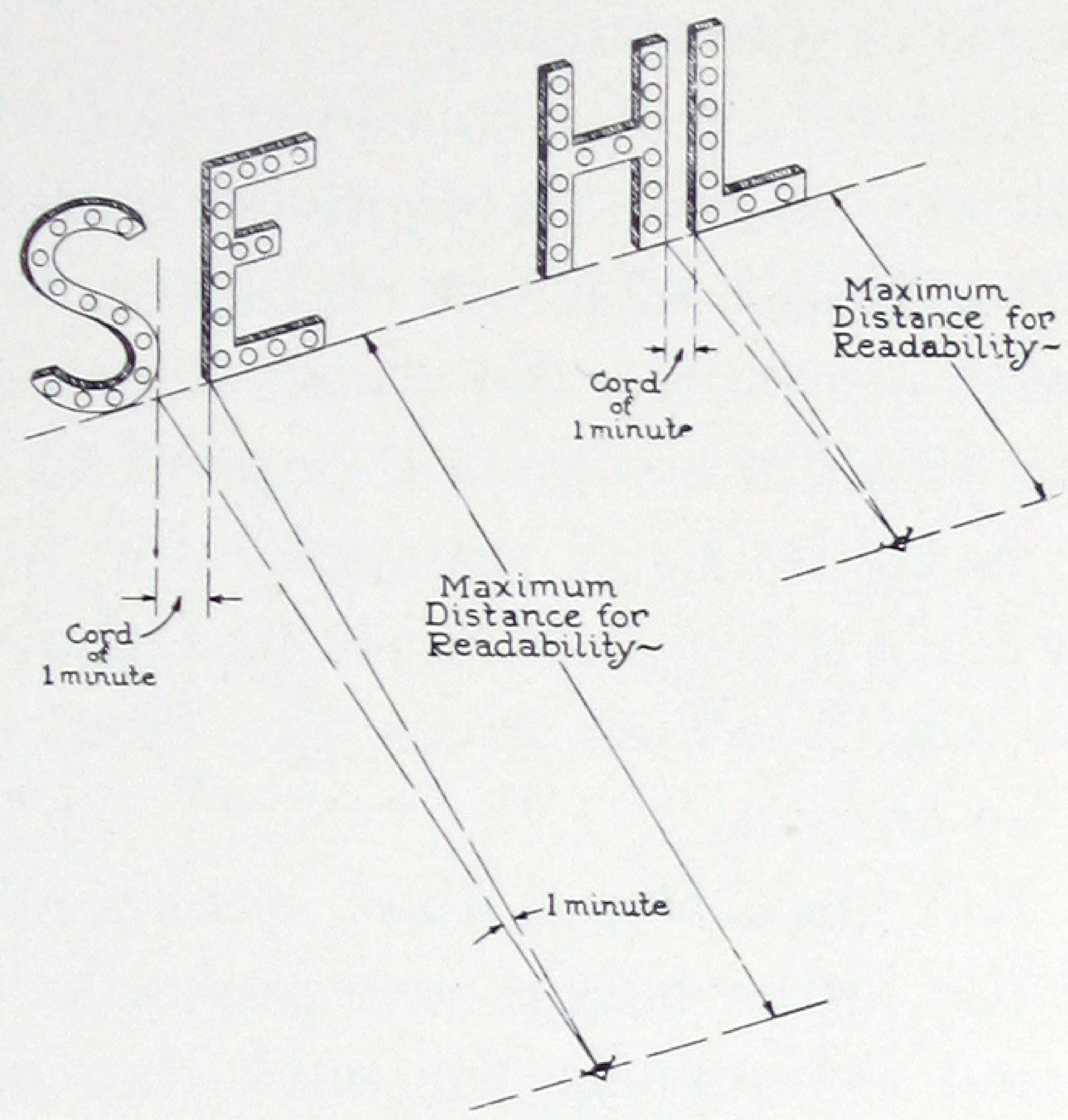

Fig. 2
Effect of Letter Spacing on Readability

quarters of the height are the best, not only from a standpoint of appearance but also because of readability.

In Table No. 1 are shown the basic proportions of stock letters as generally used.

TABLE No. 1

Height In.	Length In.	Width In.	Space In.	Voltage	Watts
24	18	4	5½	10-12—55-65-110	5-10-25
30	22½	5	7	10-12—55-65-110	5-10-25
36	27	5½	9	10-12—55-65-110	5-10-25
42	31½	6	11	110-125	10-25
48	36	8	12	110-125	10-25
60	45	10	15	110-125	10-25-50
72	54	11	18	110-125	25-40
84	63	13	20	110-125	25-50-75-100
96	72	15	21	110-125	50-75-100
108	81	18	24	110-125	50-75-100
120	90	20	27	110-125	50-75-100
144	108	24	30	110-125	50-75-100

The height of a letter also has a great effect on its readability. This is true not only because the increased height makes it visible at a greater distance, but due also to the fact that in a letter of large dimensions, the integral parts of the letter are farther apart and therefore the distance is greater from the letter to the point at which any two integral parts of the letter subtend an angle of one minute. Thus in Fig. 3, the large letter "S" would be visible at a greater distance than the smaller letter "S" because the observer could be at a point farther away from the letter and the distance between the middle and lower part of the letter would still subtend an angle of one minute.

The effect on readability due to the stroke width of letters is seemingly contradictory since in daylight the wider it is, the greater the distance of readability; while at night the readability of any given letter increases as the stroke width decreases. From these facts, it is seen that this dimension will depend to a great extent on whether the sign is to be used primarily for night or day use. Service conditions for a given sign must be balanced before deciding, and then the width which gives the best service under all conditions should be chosen.

In practice it has been found that stroke widths of from 20 to 25 per cent of the letter height are generally used. For some signs which are used extensively for both day and night service the letters have been made fairly wide, to give readability during the day. On the face of the letter and perpendicular to it have been fastened metal strips or troughs in such a position as to divide the letter face into thirds. The strips are painted the same color as the letters and thus do not interfere in any way with the appearance of the sign during the day. The lamps are placed between the two metal channels, that is, in the center section of the letter and thus at night the light from the lamps is confined by the channels and the letter appears only one-third the width seen in daytime and is evenly and brilliantly illuminated. Such letters have been tried on some of the large roof signs and have given very good results.

While from tests it has been found that certain dimensions for sign letters are best theoretically for the highest readability, yet when it comes to the actual design of signs for commercial use, these dimensions often must be changed very decidedly to give the sign its proper appearance. Often a sign which is far from being theoretically perfect, will under the conditions for which it is in-

tended give the best service. The sign engineer must consider all conditions under which a given sign is to be used, and the results desired, and then from his experience decide upon the dimensions best suited to the particular case at hand. The design of signs like that of so many articles which are put upon the market in large quantities is too likely to degenerate into a practice of following a path of least resistance, and utilizing something which has been used elsewhere, and is perhaps most particularly suited to some other purpose.

Type

Whether it is better to use a channel or flush construction of letter depends upon the size and the service for which it is designed. For large letters, such as are used on the huge roof signs,

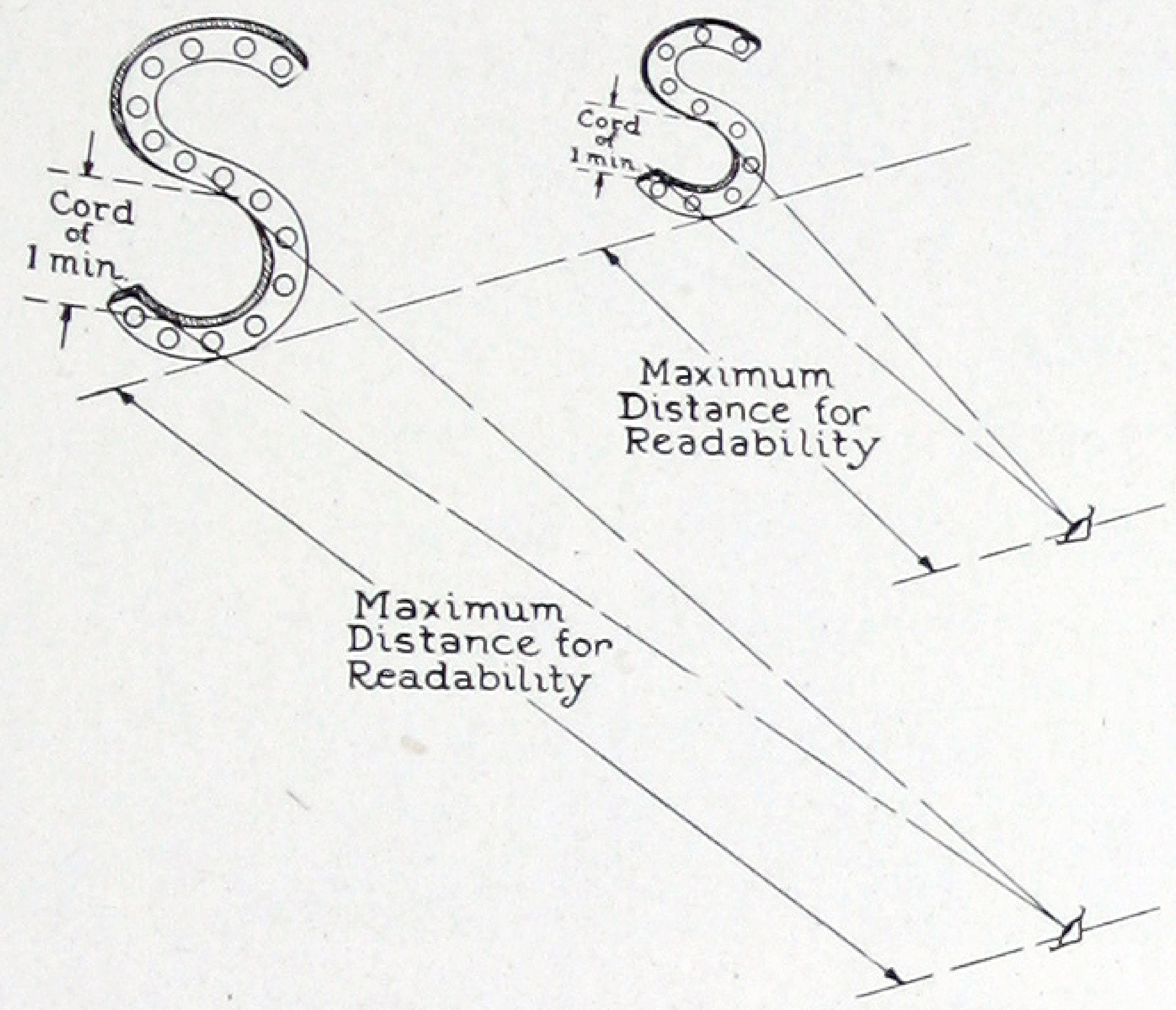

Fig. 3
Effect of Letter Size on Readability

the trough may be neglected. Here the sign is so large that it is readable at the maximum distance at which it will be visible and a trough on letters of such size would have very little effect. However, signs with the same kinds of letters used by merchants or by theaters, and displayed over the sidewalk at a comparatively low hanging height are improved by the use of troughs. The letters of such signs are seldom over five feet in height and a trough adds to their attractive appearance as well as confines the light in useful areas. The chief advantage of such a trough is increased readability when the sign is viewed at an angle, and it is also found that, as the depth of the trough is increased up to a certain limit, the readability increases.

Selection of Lamps—General Considerations

Not only is it necessary first to design a sign which is suitable for the purpose for which it is intended, but it is highly necessary that it should be properly maintained, if a good impression is to be continuously created. For instance, renewals of burnt-out lamps should be carefully attended to as the appearance of a sign with broken letters or similar defects is usually an advertisement of carelessness or incompetency of the owner and does not attract business.

In the matter of selecting lamps for signs, as in the design of letters, a number of variable factors must be considered. A huge roof sign high up on a skyscraper must have such brilliance that the sign stands out in contrast to the background. The advertiser desires to bring to the attention of the passerby a certain article with such brilliance that the idea is impressed on his mind. Such a sign must have no subdued light as is obtained by lamps equipped with some form of diffusing medium, like frosting or enameling, but rather should have a glittering brilliance, almost a glare, as obtained from a clear lamp.

While within working limits the readability of a sign decreases as the brilliance of the lamps increases, it should be remembered that signs attract by their brilliancy and the advertising value in many cases should not be lessened to improve readability.

For huge roof signs this factor may be neglected as at all times the distance between the sign and the observer is such that the brilliance is not objectionable. In present practice, the signs in large cities are of such a high brilliance that additional ones, unless they are at least of equal brilliancy with the surrounding signs, will not attract attention and their value as advertising mediums is lost. However, the smaller signs on the front of buildings and hanging close to the street must necessarily be of a much lower order of brilliancy; otherwise the observer will be blinded by the flood of light and the sign will be illegible, thus defeating its purpose. If, because of high general illumination, it is necessary to have the small, low hanging sign illuminated to a high intensity, some form of diffusing medium must be employed on the lamps in order to prevent the blinding of the observer by the high intrinsic brilliancy of the lamp filament. By using frosted lamps the appearance of signs hanging close to the street is greatly improved, especially to observers at a short distance from them, although the readability at a distance is not greatly changed.

Atmospheric conditions sometimes affect the readability of a sign to a great extent. A slightly foggy or smoky atmosphere has a tendency to cause an absorptive effect blanketing the high intrinsic brilliancy to such an extent, that it more than offsets the dispersive effect tending to blur the letters, thus causing the sign to be readable at a greater distance than in a clear atmosphere.

Fig. 4
The Importance of the Electric Sign as an Advertising Medium to Men in Every Line of Business Can be Understood by Taking a Trip up the Main Thoroughfare of Any Large City After Dark. Broadway at night, brighter than ever before, will convince the most skeptical of the importance of the illuminated sign. Keen competition necessitates the use of extremely brilliant light sources. The Sonora sign with overall dimensions of 50 by 110 feet is of the flasher type. The first part of a cycle showing the swinging bell contains 2835 10-watt regular sign and 273 75-watt regular Mazda C lamps and the second part shows the word "Sonora" in letters 13 by 23 feet lighted by 478 Mazda Daylight lamps

Although at times atmospheric conditions affect the readability of a sign, in general, the readability is independent of such conditions.

The position of a sign often determines the lamp to be used. In metropolitan districts where signs are numerous (see Figs. 4 and 5) a sign must have a sparkle and brilliance which will make

it stand out among others to such an extent that it will attract attention. In the case of a factory located near a railroad in a district where there are few electric signs, a large roof sign illuminated by lamps in diffusing bulbs will be very attractive. Here the sign will be not only conspicuous, but illuminated to a high intensity with an even whiteness, giving no glare from individual lamps. Thus we see that in the matter of choice of lamps for a sign, it is often the conditions under which the sign is to be used that will

Fig. 5
Where Electric Signs are Fewer, High Brilliancy is Not so Necessary. The above sign operated by a progressive laundry measures 54 feet in height by 40 feet in width and contains 1320 5-watt low voltage Mazda sign lamps

govern the choice of lamps, just as in the choice of letters the same conditions govern the proportions of the letters which are to be used.

For the small signs with which a trough letter would be used we have a different problem. Here we have a sign much closer to the observer, and high wattage lamps in clear bulbs would blind a person to such an extent that they would be objectionable. A more diffused or softened light is here desirable and low wattage

lamps which have been either enameled or dipped in various colors improve the appearance of the sign and attract the eye of the observer by the unique color combination of light.

Size and Type of Lamps for Large Metropolitan Roof Signs

For large signs the MAZDA Daylight lamps give a very white brilliance, causing the sign to show up in direct contrast with the background. For some of the larger roof signs the 75- and 100-watt lamps of this type are used, and they stand out in marked contrast to the surroundings. (Fig. 6.) In using such lamps it should be borne in mind that unless the sign is high above the

Fig. 6
The Fisk Tire Co. Believes in Advertising Its Product by Means of a Brilliant Flashing Sign on Broadway. A boy 55½ feet tall (not shown) is first flashed on and is followed by the words "Fisk Tires," the large letters of which are 24½ feet high and have a stroke width of 4½ feet. The whole sign is 63 by 129 feet and contains 3000 75-watt Daylight MAZDA lamps

observer the glare will be so intense that the sign becomes illegible and its whole purpose is defeated. Sign engineers should also bear in mind that lamps of high wattage in gas-filled bulbs are not designed to be burned under adverse weather conditions, nor in a horizontal position. When burned in this position the heat from the filament causes a hot spot on the upper side of the bulb, which if struck by rain will cause the bulb to crack and the lamp to burn out. Breakage of these higher wattage lamps can

be greatly lessened if some means of protection is furnished to the lamp. If the hot spot at the top of the bulb is covered by a cap in such a way that rain or snow is prevented from striking it, the chance of breakage is much less.

The simplest and most easily applied protector available is the sheet metal protector cap (Fig. 7). This cap fits the bulb closely and protects the hot glass from sudden chilling. The caps are made as small as is consistent with adequate protection and when used in the average electric sign are not visible if the lamps are burning and can hardly be detected if they are not. However, even if some form of protection is employed, the sign engineer must expect and make allowance for a higher percentage of burnouts than if lower wattage lamps are used. The protection caps will greatly lessen the injurious effect of a storm, but cannot totally prevent broken lamps. In other examples the 75- or 100-watt clear bulb MAZDA C lamps are used. They also present a brilliant appearance and make an effective sign. Methods of protection similar to those recommended for MAZDA Daylight lamps must be used and their use cannot be indiscriminately recommended because of the probability of excessive breakage. For this reason there are many cases where the 50-watt blue MAZDA B sign lamp can be used with less chance of breakage, as the bulb does not become as hot. By spacing these lamps closer an almost equal brilliance can be obtained at less cost than by using the larger gas-filled lamps.

Size and Type of Lamps for Small and Low-hung Signs

Lately it has often been found that 5- and 10-watt MAZDA B lamps for sign lighting, now in general use, do not give the desired light intensity. Today, with our standards of illumination higher than those of yesterday, signs equipped with such lamps sometimes do not even attract the eye when competing with brighter store windows and general street lighting now common to our large cities. The sign message must be left to lamps of higher power.

There are available lamps of higher wattage that meet the needs of these new signs. The new blue MAZDA sign lamp made in 25- and 50-watt sizes will increase the brilliancy of signs to such an extent that these signs will have a pleasing appearance and attract attention even in brightly lighted areas of our large cities. An example of their use is to be seen in Fig. 9.

The lamps are recommended for such use because of the added brilliancy and whiteness they give to a sign, and also because of

their sturdiness and better mechanical characteristics for such service. Since the lamps are short they may be used effectively with trough letters designed for 10-watt lamps, thus making replacement easy and new construction standard and inexpensive. Because of the coiled filament, the light source is concentrated and symmetrical and the blue glass bulb gives them the appearance, when viewed horizontally, of brilliant, white spots of light. Since these lamps are of the vacuum type, there is no chance of excessive storm breakage although the bulb is small, as there is no convection of heat to any particular part of the bulb.

Size and Type of Lamps for Talking Signs

All signs of this type, though different in appearance, according to the company manufacturing them, are essentially the same in principle. Such signs have the advantage of advertising not a single

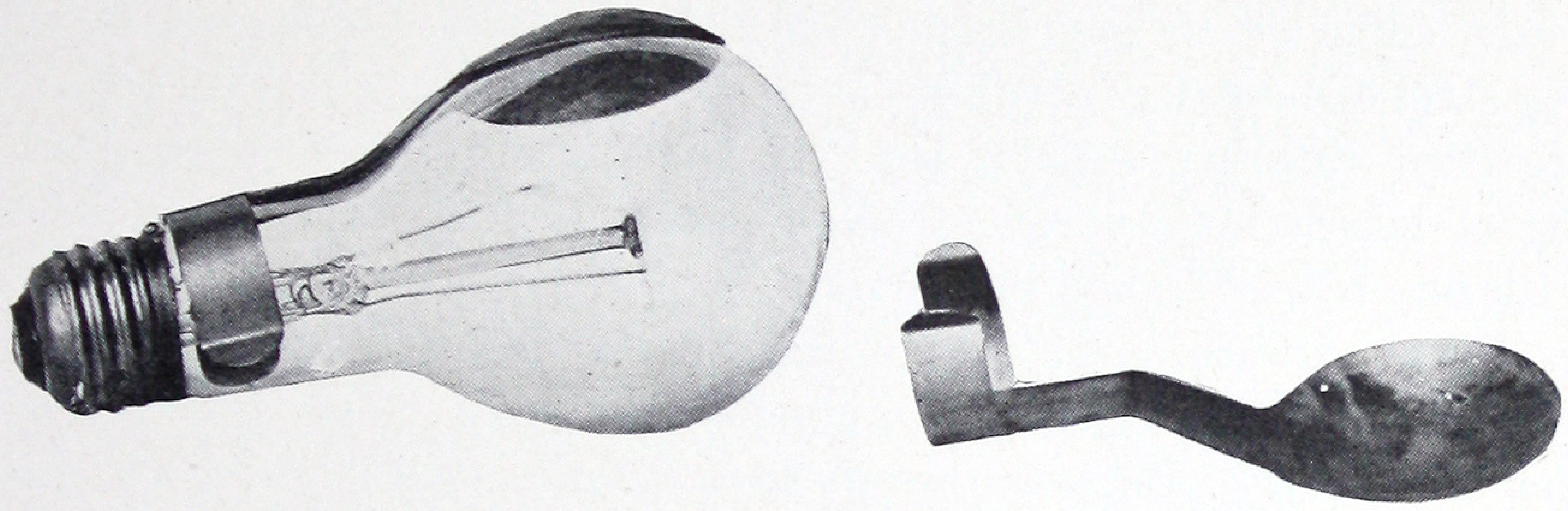

Fig. 7
Protection Caps for 75- and 100-watt MAZDA C and Daylight MAZDA Lamps

product, but several successively, each of which is flashed on for a short interval of time to be followed by an entirely different advertisement at the next flash. With each sign of this type some patented method of flashing is used to obtain the effects produced.

Since each letter space becomes virtually a mass or solid bank of lamps it is necessary to enclose each lamp in a short cylindrical metal tube. This prevents light being thrown on the face of the sign which would cause a blurring effect due to cross reflection through adjacent bulbs. These tubes have the same general effect as a trough on the regular type of sign letter.

In the past, these signs have ordinarily used the 5-watt low voltage sign lamps, but now that blue lamps for sign use are available manufacturers of this type of sign should quickly recognize the advantage of the coiled filament construction with its high end on candle-power (see Distribution Curves, Fig. 8). The use

of such lamps would greatly increase the brilliance and illumination of the letters, thus bringing the advertised product more forcibly to the eyes of the public and increasing the value of the sign as an advertising medium.

Spacing of Lamps

It is obviously desirable to have the stroke of a letter appear uniform and continuous. Spotted effects are unsightly under these conditions, and if we are seeking uniform illumination the spacing will be partly dependent on the wattage used, and the wattage in turn dependent on the size (width) of the stroke.

When extremely wide letters are used, as in signs with letters of the Old English style, it may be desirable to place the lamps along the outside edges of each stroke. In daylight such letters are readable at a great distance and at night they appear very distinct, being outlined in light with a darker portion in the center of the stroke.

In such letters spacing between the two rows of lamps in any one stroke is not a governing factor in readability, unless the strokes are very wide in comparison to the spacing between letters. Spacing of lamps in any row of such letters is the same as in letters with one row of lamps per stroke.

From experimental data it has been determined that for various lamps used in the illumination of signs, there is a certain spacing distance between lamps of a definite size beyond which it it not advisable to go. If a wider spacing is used light from adjacent lamps does not overlap sufficiently to furnish even illumination. However, spacing distances between lamps less than that recommended may be used if a higher intensity and greater brilliance is desired for a given sign.

Table No. 2 shows the maximum spacing recommended for the various lamps used in sign lighting.

TABLE No. 2

Lamp Size	Spacing Inches	Lamp Size	Spacing Inches
5-watt Mazda sign lamp	5	50-watt White Mazda C lamp	8
10-watt Mazda sign lamp	5	75-watt Mazda C lamp	9
25-watt blue Mazda sign lamp	6	75-watt Daylight Mazda lamp	9
50-watt blue Mazda sign lamp	7	100-watt Mazda C lamp	10

Color and Flashing Effects

A touch of color gives charm and interest; an overload of color looks crude and undignified except in very rich and spectacular displays. The most desirable colors are opal and yellow on account of their low absorption. Ruby or red is also much used and is

distinguishable at great distances. Green, blue and purple are not efficient for many practical purposes and are not to be generally recommended. Lamps of warm, contrasting colors give pleasing effects. In general, a solid mass or continual line of color is more attractive than a mixture of colors, as the introduction of different colors breaks the continuity of outline and thus detracts from the effect.

Color caps or color shades are a substitute for natural colored glass lamps or dipped lamps. The advantage over the former is that they are less expensive in the long run and over the latter that they will stand the weather while the color on a dipped lamp will generally wash off when exposed to rain. They also have the

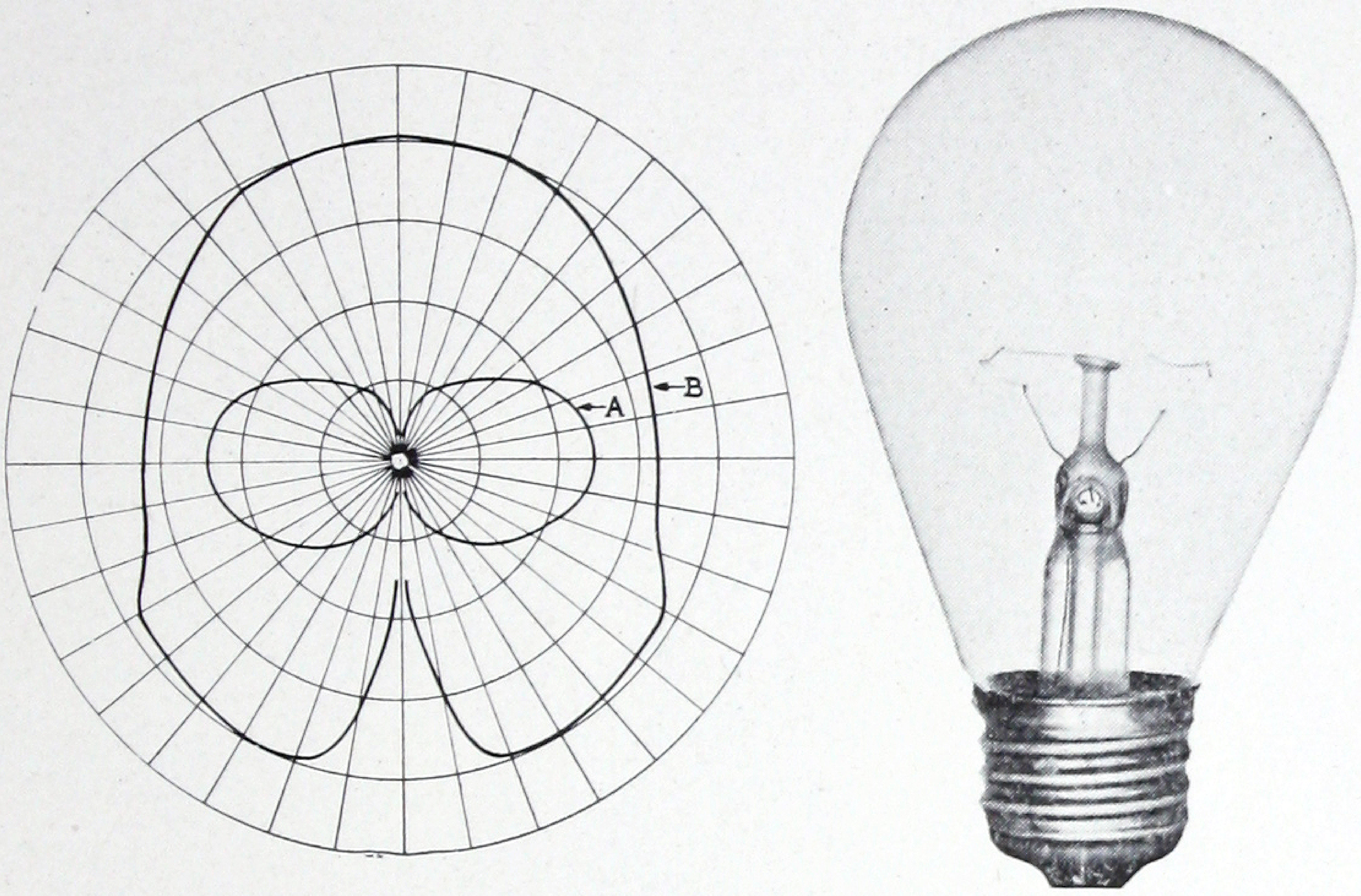

Fig. 8
The New 25- or 50-watt Blue Mazda B Sign Lamp and Comparative Distribution Curves of A 10-watt Sign Lamp and B 25-watt New Blue Sign Lamp

advantage of being readily changed and a man can have a red effect on his sign one week and blue the next week, if he so desires, at a comparatively little extra cost.

With either large or small signs of this type the aid of a flasher is desirable. A large and very brilliant sign will often attract attention much more quickly if it is flashed on and off, either wholly or in part, according to the form of the advertisement, than if it remains lighted at all times. In the case of smaller signs attention is attracted much more quickly when colored border lamps are flashed on and off, giving momentary lighting effects, which represent fountains, serpents, rolling wheels or various other attractive designs that fit the advertisements shown. Then

also the motor flasher is a money saver, since for the same sign from 30 to 50 per cent in power consumption may be saved by flashing, rather than by leaving it continuously illuminated. Whether a sign should be continuous or flashing, whether the bulbs used should be clear, frosted, or colored, whether different colors should be flashed on and off, whether different colors should present the same or different messages, and whether the flashing sign should depict some motion or mechanical operation, are all matters which must be studied with reference to the subject, and to the impression that will be made on the observer.

Signs with Concealed Lamps

The various forms of signs lighted from the interior often present a very good appearance and this makes possible at a small cost an advertising medium which will yield good returns.

Most of these signs employ relatively large lamps placed within a housing. One form is known as the bull's-eye sign and has a quite wide general use. It consists of a box of metal, water tight and dust proof. Meniscus lenses are set in holes punched in the face of the sign. The light from the concealed lamps is transmitted through the lenses which therefore take the place of bare lamps in the first type of sign and present a somewhat similar appearance. The daylight effect of such a sign is usually good, but at night unless careful design is carried out spotted effects are quite likely to prevail due to the unequal lighting of the various lenses. One means of overcoming this effect is to utilize a number of small reflectors inside of the housing to direct the light uniformly on the various lenses.

Another form of sign is known as a cut-out. Here the outline of the letter is punched through the outer face and letters are set inside with a small space between the letter itself and the face of the sign. Light from lamps inside of the casing strikes the white face of the letter, causing it to be uniformly illuminated. On account of the open spaces, the sign is neither dust nor rain proof and with darkened surfaces the reflecting power is soon diminished. Coatings of dust very frequently must be removed. If lamps are so placed that rain drops may strike them water cracks are likely to be caused, resulting in early burnouts. Difficulty may also be experienced with the wiring unless it is so protected as to eliminate the possibility of it being harmed by water.

Another widely used and justly popular, inexpensive sign is known as a glass panel transparent sign. In this a light density glass plate is fastened tightly against the face of the sign from which

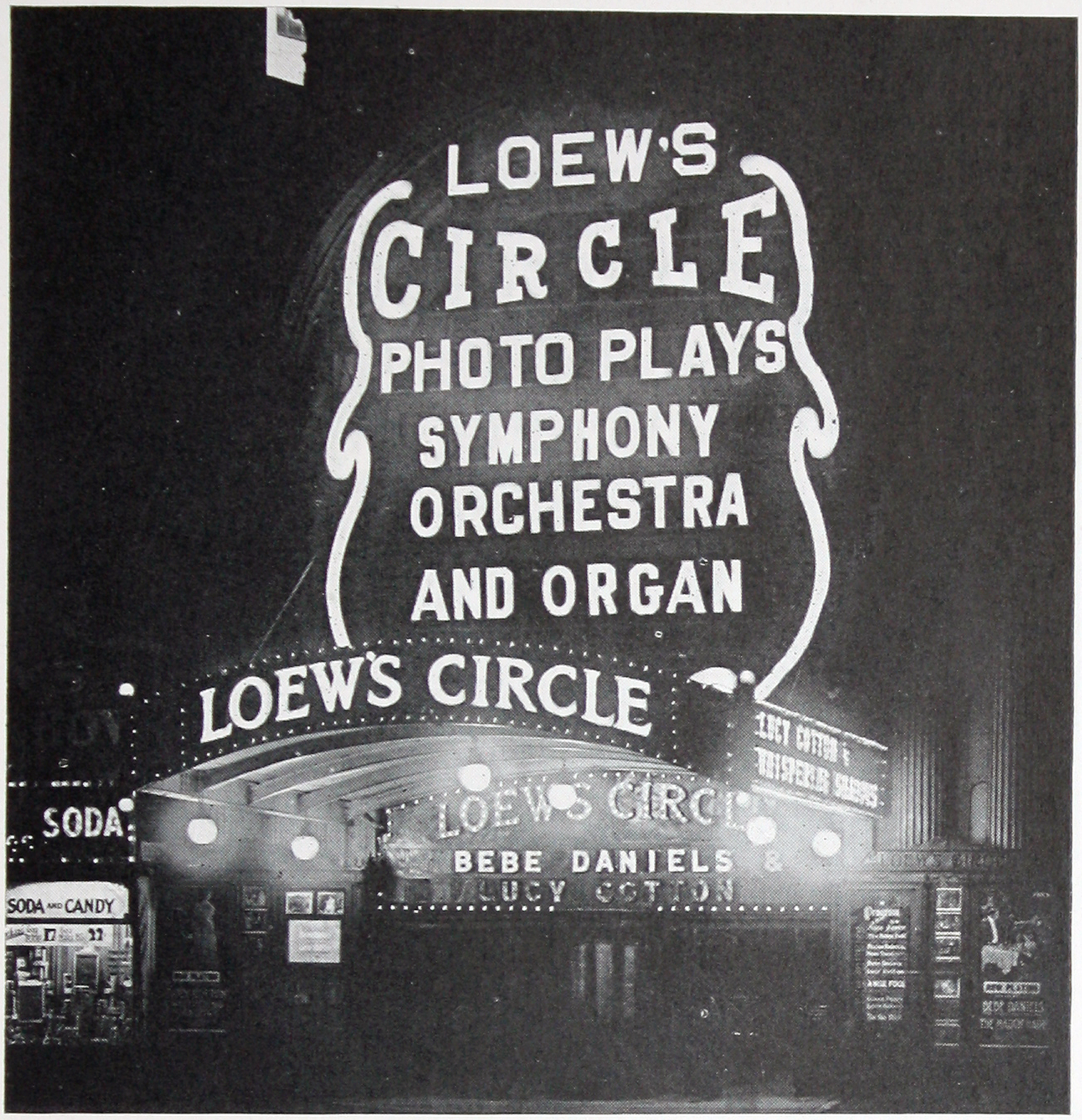

Fig. 9
Theaters Must Employ Brilliant Electric Signs for Advertising Purposes. Such signs which are customarily close to the sidewalk cannot use the high wattage Mazda C lamps due to the glare at close range. The new 25-watt blue Mazda sign lamp is very well adapted for use in signs like the one above where a clear white letter is desired. The border of 10-watt regular Mazda sign lamps with color caps presents a pleasing contrast to the white letters

letters have been cut. Light from large lamps inside of the casing is transmitted through the glass and the letters show up in contrast with the black background. This form of sign can be made dust and water proof and hence be operated economically. Its

appearance can be greatly improved by using colored glass plates to emphasize the message. As with any sign of this general nature, the distribution of light over the face should be even. A frequent painting of the interior of the sign a flat white is therefore a decided asset as the white surface acts by diffuse reflection giving a uniform intensity throughout.

A modification of this general type of sign which has special advantages is made by punching the face of the metal in the form of a stencil. Letters of opal glass are then fastened to the inside

Fig. 10
The Sign with Opal Letters, Illuminated by 75-watt Mazda Daylight Lamps Presents a Pleasing Appearance and Attracts Attention to a Store During the Dark Hours. Such a sign with its white diffused light even though mounted low allows no chance of blinding the passerby

of the face. These are curved so that they project an appreciable distance out from the metal, enabling one to read the sign at a greater angle than if flat letters were used. An example of this type is shown in Fig. 10.

In practically all signs of this type the light is in some way diffused and hence little of the brilliance and glitter found in signs with visible lamps is present. If such signs are used in the presence of even much more brilliant effects, they will often appear to be rather dull, due to the predominant yellowish light of the clear bulb lamp. The use of Mazda Daylight lamps proves valuable here, overcoming the dull appearance, making the letters stand out and appear much more brilliant. 75-, 100-, 150- and 200-watt Mazda C or Mazda Daylight lamps are useful in such signs as under discussion, the proper size of lamp depending on the dimen-

sions of the sign and its location. Although the smaller sizes are less efficient, it is frequently desirable to employ a number of these rather than a few large lamps, on account of the greater uniformity of illumination thus secured.

Billboards and Large Painted Signs

The methods of lighting billboards and large painted signs are of an entirely different character from those described in the preceding section. In this case the illumination is furnished by units placed in front of the board in such a manner as to direct the light on the message, which we see by reflected rather than by direct or transmitted light. In order that the sign may be bright enough to attract attention and stand out prominently, the units must be fairly large to produce a high intensity; the light sources must be concealed from the eye so that glare will be eliminated, for in this case the board with its advertising message is the object to be seen, not several high intensity brilliant light sources.

Reflected glare must also be eliminated by placing the light source in the proper position. It would be better if signs which are viewed from below had the units mounted at the base to throw their light upward on the board as the angle of incidence would be such that the reflected light would be upward and therefore not in the direction of the observer. With signs viewed from above the position of the light sources should be reversed, that is, placed at the upper edge so that the reflected glare will be thrown below the observer. This practice, however, introduces some structural and maintenance difficulties, so for most conditions light sources placed well above the board meet the operating conditions. However, the higher the units are mounted above the board the more concentrated the distribution will have to be in order to utilize the light effectively. At the present state of the art there is no standard low cost unit for outdoor use which gives exactly the desirable distribution so a compromise must be effected.

The general practice is to mount lamps and reflectors at the lowest point where they will not interfere with the view of the board and to ignore the effects of reflected glare, since the sign is usually viewed from a considerable distance. In cases where the glare effect is severe it can be largely eliminated by employing dull rather than glossy finish paint.

Porcelain enameled reflectors have been found to be low in cost and stand up well under severe weather conditions. The enamel finish does not deteriorate or accumulate an excessive

amount of foreign material and the dirt which does gather on the reflecting surface can be readily removed by washing. These reflectors are small, compact, of light weight, thus allowing them to be suspended far enough in front of the board to give a uniform distribution of light without causing excessive strain on the mechanical support or casting large shadows on the face of the board during the daytime.

Mazda C lamps of the various sizes are ordinarily employed in the angle type reflectors. If these are properly placed and spaced with reference to the board, very little of the light will be lost and the distribution of the angle reflector is such that the maximum light is directed toward the bottom of the board, tending toward uniform illumination.

It is evident that the illuminated sign can never be as brilliant as the one with visible lamps, yet it must be lighted to a sufficiently high intensity for it to stand out from its surroundings. It must be very attractively designed in order to meet the more severe competition of its glittering, brilliant neighbors. Uniform illumination is naturally a factor in attractive appearance. Individual porcelain enameled, angle reflectors have been found by test to be of a higher efficiency and more durable than some cheaply constructed reflectors often employed, and it is not good practice to sacrifice efficiency and durability for a low first cost.

In designing the lighting equipment for any billboard, the desirable intensity, of course, depends upon the general illumination of the locality and the character of surrounding signs.

The data given in Table No. 3 apply to billboard lighting under usual conditions, that is, for boards situated in well lighted districts. Where the surrounding intensities are particularly high, larger units than those specified should of course be employed in order that the board will be at least as brilliant as its surroundings.

Although boards of the dimensions given are found in practice, the ones most often employed are those from 9 to 12 ft. in height. From Table No. 3 it is seen that 200-watt Mazda C lamps equipped with the proper size of porcelain enameled, steel, angle reflectors are recommended for use with boards of this size. With units mounted as recommended on these 9-ft. by 12-ft. boards an intensity of about 900 candle-power is projected at an angle of approximately 35 deg. from the vertical, striking the board at about one foot from the bottom. From this point up the intensity gradually decreases to about 400 candle-power in the horizontal

direction or in line with the top of the board. Taking into consideration the distance between the light source and any point on the board and also the angle at which the light strikes the board at that point, the intensity of illumination from the top to the bottom of the board will be approximately uniform.

The tendency is to mount units too close to the board, causing poor illumination. The advantage gained in mounting the units far out from the sign offsets the cost since the distances from the unit to the top of the board and from the unit to the bottom of the board are more nearly equalized, thus the light is more evenly distributed, and the highest intensity is directed toward the bottom of the board without the necessity of tilting the reflector at such an angle that the top of the board is in shadow.

TABLE No. 3

SPECIFICATIONS FOR BILLBOARD ILLUMINATION

Height of Board Feet	Mounting Dimensions of Lighting Units			Size of Lamp Watts	Ave. Ill. Foot-candle
	Spacing Feet	Distance Out Feet	Distance Above Feet		
3–5	5	4	1	75	9
6–8	6	5	1	100	9
9–12	6½	7	1	200	10
13–17	9	8	1½	300	11
18–21	12	11	2	500	10
22–25	16	15	2	750	11
25	20	18	2	1000	10

In installing lighting equipment for a billboard, accessibility of the units should always be given consideration. The units should be so mounted that they can be reached regardless of the weather conditions as by this means much time and labor can be saved. The mounting should be of such a character that the supports will withstand any wind pressure that tends to displace them from their proper positions.

Most reflectors for this type of lighting are tapped for ½-in. pipe and this size of pipe is sufficiently rigid for most conditions. For small signs up to six or eight feet in height the pipe can be screwed into a bracket fastened to the top of the board. By attaching junction boxes to each bracket and carrying the feed wires from bracket to bracket along the top of the sign in steel armored duplex cable, a very neat and durable installation can be secured.

Most standard boards are from 9 to 12 ft. in height and since the units must be placed farther out a different mounting should

be used. The lighting equipment out in front of the board can be balanced and stabilized by running the conduit pipe along the back of the board about five feet below the top with junction boxes spaced at intervals equal to the distance between lighting units, and then extending conduit from each box up the back of the board and by means of right angle bends out over the top of the board the proper distance to the reflector.

The unit is prevented from swaying by means of guy wires from the reflector to the top of the board. For cleaning the unit,

Fig. 11
Two Groups of Well Designed Properly Maintained Billboards as Found in California. The lighting equipment is neat and inconspicuous. Advertising of this character is certainly an asset to the community

it is only necessary to detach the guy wires and swing the reflector in toward the face of the board. Thus the danger of using ladders out in front of the board in exposed places is eliminated.

For larger boards up to 20 ft. in height where the units must be placed still farther out, the same method of mounting may be used if an additional supporting guy is carried in from the unit to a support about five feet above the top of the board. For boards over 20 ft. in height, heavier pipe, securely trussed and braced, can be used if a firm support above the board can be ob-

tained. When firm supports are not obtainable above the board a cable may be stretched parallel to the face of the board at the proper distance above and in front and the units can be suspended on this cable with the proper spacing. By means of arc lamp hangers the units can be hung in such a manner that they can be lowered to facilitate cleanings and renewals.

Billboards and painted signs located in inaccessible places or at considerable distances from the power supply are usually illuminated by flood lighting projectors. These employ concentrated filament lamps in properly designed reflectors of the parabolic type and direct a concentrated or spread beam, as occasion demands, on the sign. This method is discussed in detail in bulletin Index 95.

An interesting and effective innovation in billboard lighting is the application of color effects. Colored objects present different appearances when illuminated by various colors of light. Red light falling on a blue object makes it appear black; green light falling on a yellow object makes it appear green. A red object on a white background, if illuminated by red light, appears practically invisible, for both the object and the background are equally luminous. Similarly, green light would cause a green object to blend with the background and be invisible.

It can be readily seen that by proper painting of the sign and the application of suitably tinted light, complete changes are possible as the light is changed by means of a flasher. The same board may thus present two or more messages in a novel manner. An appreciation of color effects can be obtained with a little experimentation and these principles utilized in planning billboard lighting.

The billboard is generally looked upon as an eye-sore in a community, and many times this view is justified. The more progressive concerns are realizing that it is necessary to overcome public opinion and are installing well designed, substantially constructed, artistic boards. Many of these even have small garden plots in front and are surmounted by ornamental decoration (Fig. 11). By the use of artistically designed posters or well painted signs such billboards become in reality an asset rather than a liability to the community. They serve to hide many an unsightly vacant lot and the better class are really attractive. Artificial illumination of these boards is particularly important in order that they may yield the maximum return on the relatively

high investment. Color effects herewith mentioned can be skillfully applied—the units should, of course, be neat and as inconspicuous as possible.

Wiring Calculations for Signs

The design of the wiring for electric signs of any kind is important. Wiring of insufficient capacity to carry the connected load causes the lamps to burn under voltage. Incandescent lamps should always be burned at their rated voltage; if the actual voltage is lower than the rated voltage the brilliancy of the lamps will be materially decreased. Care should always be taken that lamps of the voltage actually obtained at the sockets are used, as nothing else spoils the appearance of a sign as much as the dim, reddish glow obtained when the lamps are burned under voltage. The fire underwriters' regulations, as to size of wire in order that fire risks from overheating will be eliminated, must of course be adhered to, but in most cases if wire of sufficient size to prevent an appreciable voltage drop is used, this factor is taken care of automatically

Before designing the wiring certain data must be available.

1. Number of lamps in multiple.
2. Wattage of lamps.
3. Voltage of lamps.
4. Kind of power (a-c. or d-c.).
5. Allowable voltage drop.
6. Size of wire to be used.
7. Length of feeders in feet.

Knowing the first four and any two of the last three, the remaining factor can be obtained by calculation. From the number of lamps and wattage of each, we can determine the total wattage which if divided by the lamp voltage will give the necessary current in amperes.

From the following simple formulae and tables, the calculations for any sign circuit can be determined:

$N \times w = W$ If N is the number of lamps in multiple
w is the wattage of each lamp.

$\frac{W}{E} = I$ W is the total wattage

E is the voltage of lamps.
I is the current in amperes.

$D = KIL$ D is the voltage drop
L is the length of feeders in feet
K is a constant dependent on size of wire and whether a-c. of d-c. is used.

TABLE No. 4

DATA FOR SIGN WIRING CALCULATIONS

Size B.&S.	Amperes Rubber Ins.	Amperes Other Ins.	*K.* D-C.	*K.* A-C.
14	15	20	.00526	.00585
12	20	25	.00334	.00367
10	25	30	.00208	.00232
8	35	50	.00131	.00145
6	50	70	.000823	.000913
5	55	80	.000652	.000725
4	70	90	.000518	.000575
3	80	100	.000410	.000456
2	90	125	.000325	.000362
1	100	150	.000257	.000287
0	125	200	.000205	.000227
00	150	225	.000162	.000180
000	175	275	.000130	.000143
0000	225	325	.000102	.000113

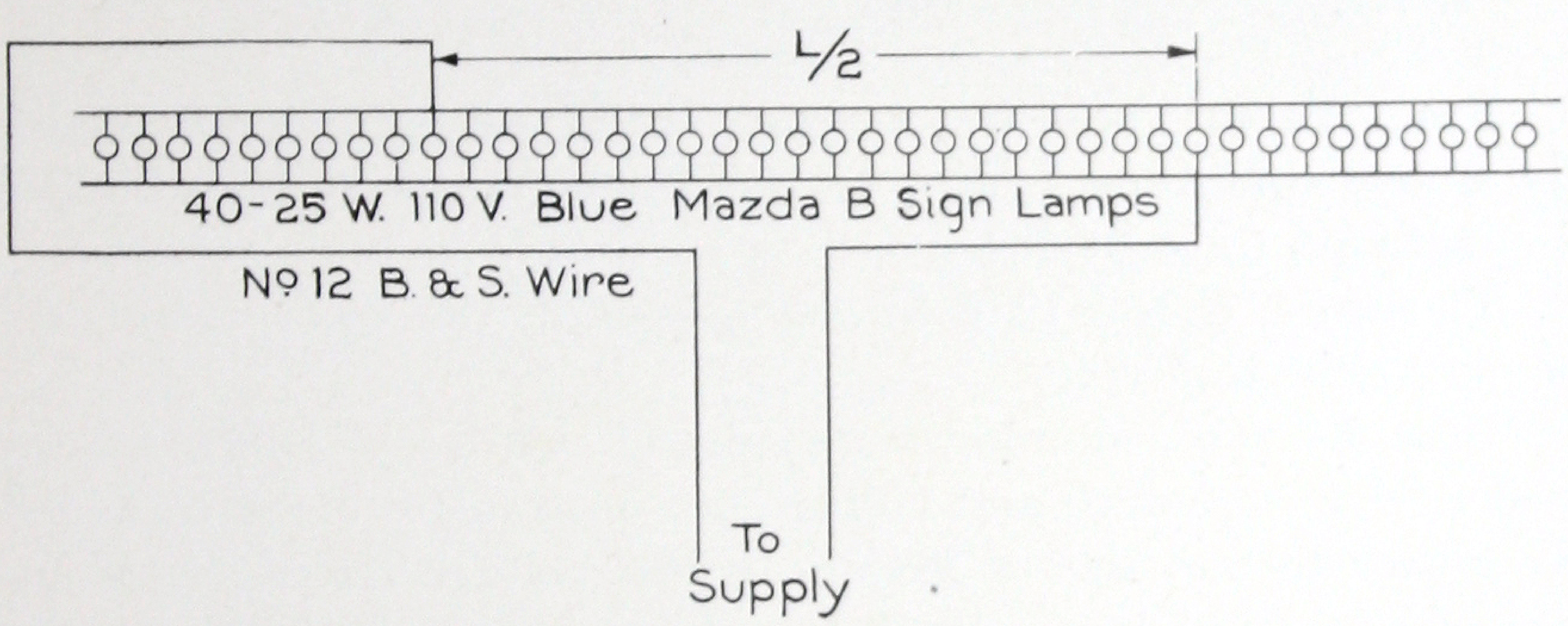

Fig. 12
Diagram Showing Wiring Connections for 110-volt Lamps on A-C. or D-C. Service

The use of the formulae and table given above is illustrated in the following problems:

Case 1.—Size, number and voltage of lamps known. Feeders of fixed length and size installed. Necessary to determine voltage of supply which will cause lamps to operate at rated voltage. (See Fig. 12.)

Number of lamps in multiple	40
Wattage of lamps	25
Voltage of lamps	110
Power	A-C.
Size of wire	No. 12
Length of feeders in feet	100

Required to find the drop between the lamps and power source.

The total wattage $= 40 \times 25 = 1000$ watts

The current $=1000 \div 110 = 9.1$ amps
K for No. 12 wire on an a-c. circuit $= .00367$
$D = K \times I \times L = .00367 \times 9.1 \times 100 = 3.34$ volts.

Therefore, the voltage furnished at the source to give 110 volts at the sign must be $110 + 3.34$ or 113.34 volts.

Case 2.—Size, number, wattage and voltage of lamps known, length of feeders and voltage of supply fixed. Necessary to determine size of wire which gives the permissible drop. (See Fig. 12.)

Number of lamps in multiple	40
Wattage of lamps	25
Voltage of lamps	120
Voltage of supply	125 D-C.
Allowable drop in volts	5
Length of feeders in feet	150

Required to find the size of wire to be used for feeders.
Total wattage $= 40 \times 25 = 1000$
Current $= 1000 \div 120 = 8.33$
$D = K \times I \times L$

$$\text{or } K = \frac{D}{I \times L} = \frac{5}{8.33 \times 150} = .004$$

From Table No. 4 the nearest size of wire which will satisfy the above conditions is No. 12 B.&S., the factor K for which on d-c. is found to be .00334.

Therefore, if No. 12 B.&S. wire is used, the voltage drop will be very close to 5 volts.

Case 3.—Size, number, wattage and voltage of lamps known, feeders of fixed length and voltage tap on transformer determined. Necessary to find size of feeders to low voltage transformers and size of wire from low voltage transformers to individual circuits. (See Fig. 13.)

Twelve hundred 5-watt, 11-volt lamps in 60 circuits of 20 lamps each. Low voltage circuits are supplied through 6 1000-watt, 110/12-volt transformers having 10 20-lamp circuits on each transformer. The main transformer supplies a low voltage of 112 volts.

1st. To find size of feeders to low tension transformers.

No. of lamps	1200
Wattage of lamps	5-watt
Voltage of high side of sign transformers	110-volt
Voltage of supply	112-volt A-C.
Allowable drop	2 volts
Length of feeders in feet	100 feet

Total wattage $= 1200 \times 5 = 6000$ watts
Current $= 6000 \div 110 = 54.5$ amps.

$D = K \times I \times L$

$$\text{or } K = \frac{D}{I \times L} = \frac{2}{54.5 \times 100} = .000367$$

From Table No. 4 the nearest size of wire which will satisfy the above conditions is No. 2 B.&S., the factor K for which on a-c. is found to be .000362. Therefore, the main sign feeders will be of No. 2 B.&S. wire.

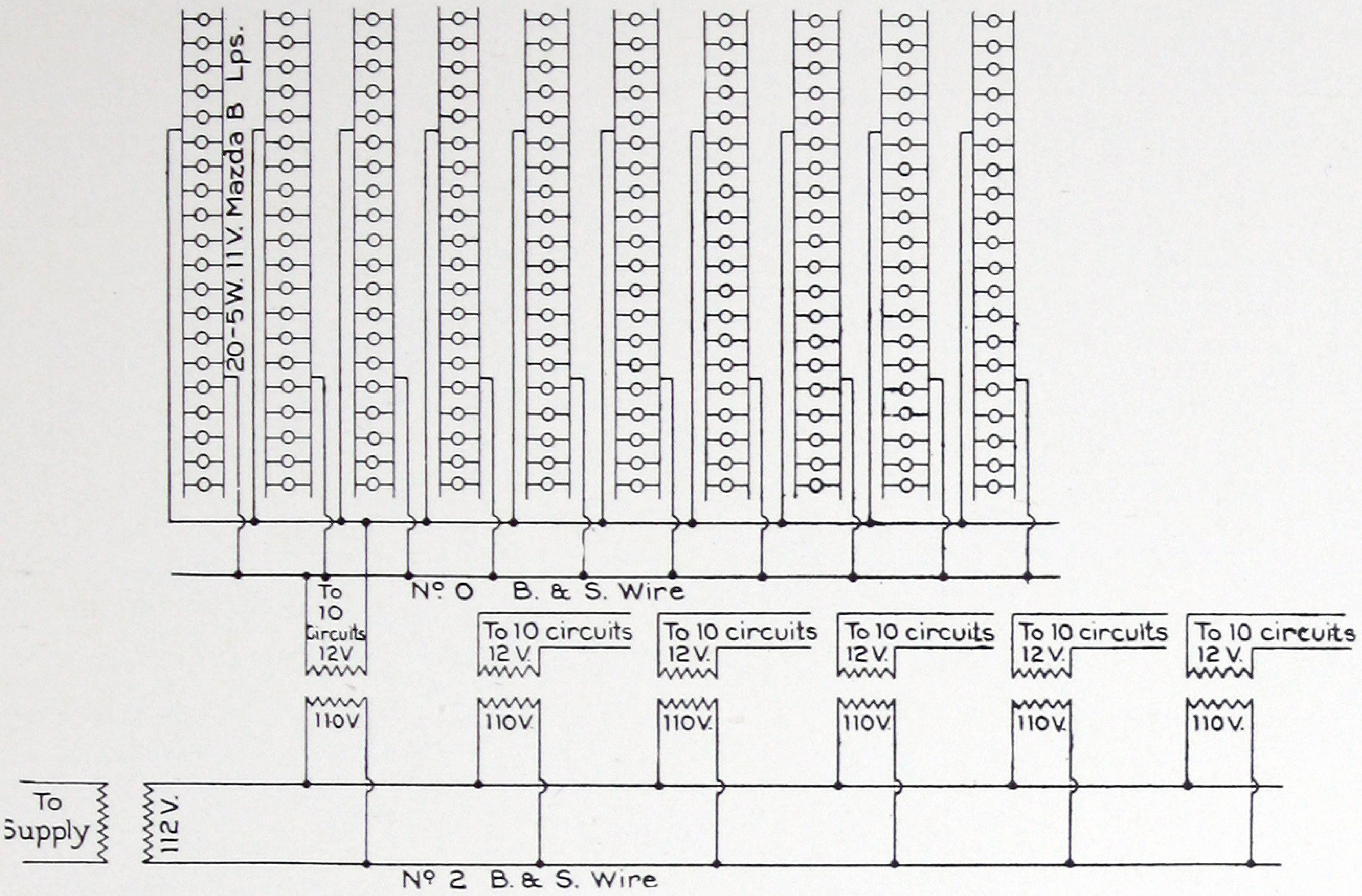

Fig. 13
Diagram Showing Wiring Connections for 11-volt Lamps with Transformers on A-C. Service

2nd. To find size of wire from low tension sign transformers to individual sign circuits.

No. of lamps	$10 \times 20 = 200$
Wattage of lamps	5-watt
Voltage of lamps	11-volt
Voltage of transformer	12-volt
Allowable drop	1 volt
Length of feeders	40 feet

Total wattage $= 200 \times 5 = 1000$ watts
Current $= 1000 \div 11 = 91$ amps.

$$D = K \times I \times L$$

$$\text{or } K = \frac{D}{I \times L} = \frac{1}{91 \times 40} = .000274$$

From Table No. 4 the nearest size of wire which will satisfy the above conditions is No. 0 B.&S., the factor K for which is .000227. This will allow for the drop in the individual circuit of 20 lamps each.

Data on Mazda Lamps Used for Sign Lighting

The application of certain standard lamps to sign lighting has been outlined in the text and the following essential technical data are presented as an aid to the designing engineer.

TABLE No. 5

Watt	Type	Voltage	Average Hours Life	Bulb	Diam. in In.	Max. Over-all in In.	Standard Pack. Quantity
5	Cl. MAZDA B	11 to 12½	1500	S-14	1¾	4¼	100
5	Cl. MAZDA B	55 to 65	1500	S-14	1¾	4¼	100
10	Cl. MAZDA B	110, 115 and 120	1500	S-14	1¾	4¼	200
25	Blue MAZDA B	110, 115 and 120	1000	P-19	2⅜	4¼	125
50	Blue MAZDA B	110, 115 and 120	1000	P-19	2⅜	4¼	125
50	White MAZDA C	110, 115 and 120	1000	PS-20	2½	5⅛	100
75	Cl. MAZDA C	110, 115 and 120	1000	PS-21	2¾	6⅛	64
75	MAZDA Daylight	110, 115 and 120	700	PS-22	2¾	6⅛	64
100	Cl. MAZDA C	110, 115 and 120	1000	PS-25	3⅛	7⅛	24
100	MAZDA Daylight	110, 115 and 120	700	PS-25	3⅛	7⅛	24

For billboard lighting the standard MAZDA C lamp from 75 to 1000 watts, 110, 115 or 120 volts and from 100 to 1000 watts, 220, 230, 240 or 250 volts are used as discussed in detail on the section applying to the subject.

Bibliography

"Electric Sign Lighting," Editorial, *Electrical Review and Western Electrician*, September, 16, 1911.

"Sign Lighting," O. P. Anderson, Trans. I. E. S. Vol., VI, page 377.

"Light—Its Relation to Electric Signs," H. J. Mahin, *Good Lighting and Illuminating Engineer*, November, 1912.

"Electric Sign Lighting with Tungsten Lamps," O. P. Anderson, *General Electric Review*, March, 1913.

"The Design of Illuminated Signs," Arthur H. Ford, Trans. I. E. S., Vol. IX, pages 445 and 553.

"Readability Curves and Their Use in Electric Sign Design," R. E. Cleveland, *Lighting Journal*, June, 1915.

"Sign and Building Exterior Illumination by Projectors," R. W. Mackall and L. C. Porter, *General Electric Review*, April, 1915.

"Lighting of Billboards and Large Painted Signs," *Signs of the Times*, May, 1915.

"Sign Lighting," L. G. Shepard, University of Pennsylvania, I. E. S. Lectures, page 535.

"The Development of Electric Sign Lighting," E. A. Mills, Trans. I. E. S., Vol. XV, page 363.

"Studies in the Economies of Sign Lighting," E. L. Elliot, *Central Station*, March, April, and May, 1920.

"Illuminated Signs," E. C. Leachman, Ill'g. Eng. (London), March, 1921.

"Problem Solved in the Use of Daylight MAZDAS in Electric Signs by Protective Caps," C. A. Atherton, *Signs of the Times*, April, 1921.

"Blue MAZDA B Sign Lamp Developed to Meet Need for Brighter Sign Illumination," C. A. Atherton, *Signs of the Times*, May, 1921.

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